Off−line calibration and monitoring

Olga Kodolova

Calibration & Monitoring Scenario (HB/HE)

(same to HF)

1) Before megatile insertion
- megatile scanner: all tiles
- moving wire source: all tiles

2.1) After megatile insertion
- moving wire source: all tiles / 2 layer
- UV laser: 2 layers/wedge

2.2) After megatile insertion
- test beam: a few wedges.

correspondance source−testbeam

3) Before closing the CMS
- moving wire source: all tiles
- UV laser & blue LED: all RBX

(do 3, about once/year)

4) Beam off times
- moving wire source: 2layer/wedge
- UV laser: 2 layer/wedge
- UV laser & blue LED: all RBX

5) Beam on
- in−situ ECAL+HCAL

Absolute calib.
Accuracy of 2%
for single particle

Monitor for change
with time
Accuracy < 1%

a few times/day (?)

once/year

Testbeam

HB a few wedges

HE using cosmic rays+ testbeam of 1 segment

HB−HE transition area to testbeam

HF each sector to testbeam + 2 sectors together

List of tasks

In collaboration

Calibration

− Calorimeter level energy scale

−> Initial calibration with test−beam, source, etc ***(with DSC team)***

−> Hermecity (HE−HF boundary, HF wedges)

−> in−situ (isolated particles, gamma/Z+jet, mass(jj))

−> jets/MET energy scale ***(with physics objects team)***

Monitoring

−> synchronization ***(with DSC team)***

−> dead/hot channels

−> radiation damage

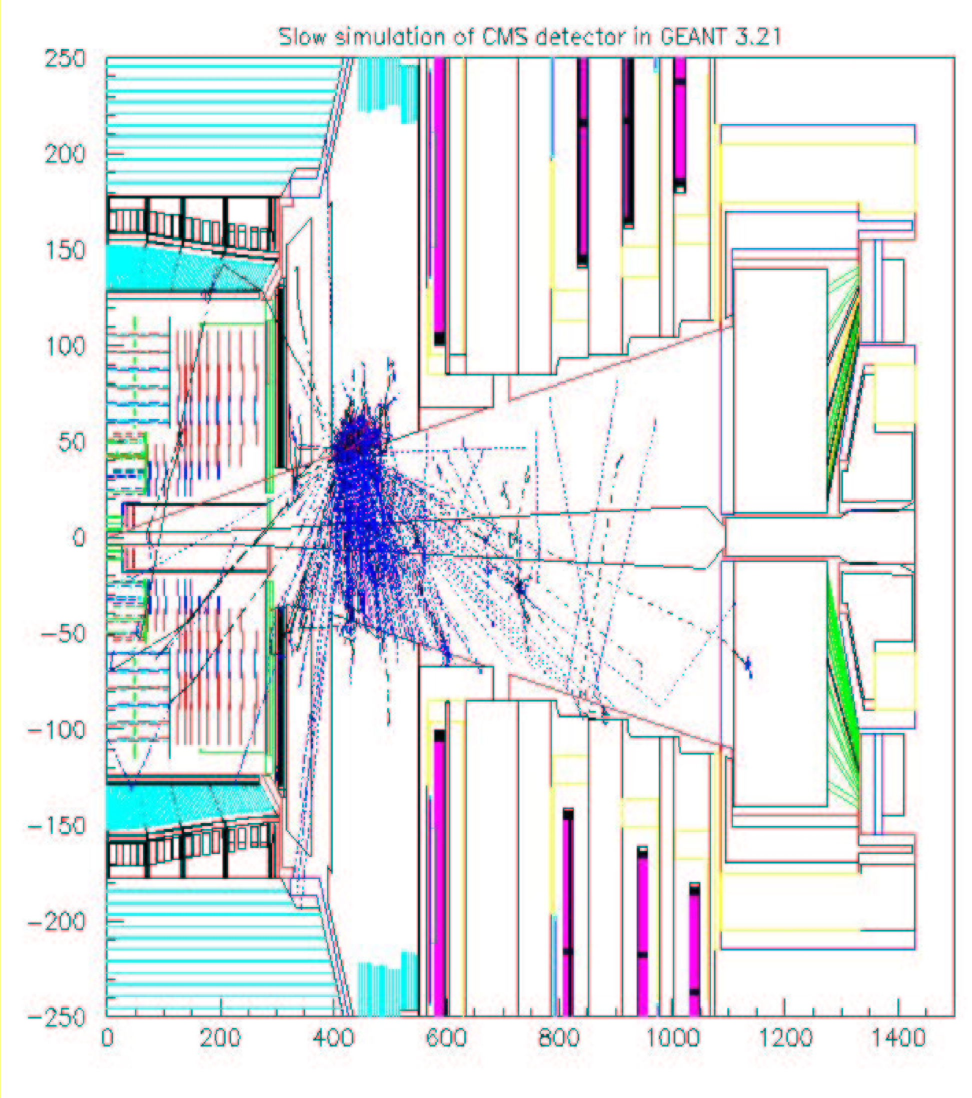
Software tools and data maintenance

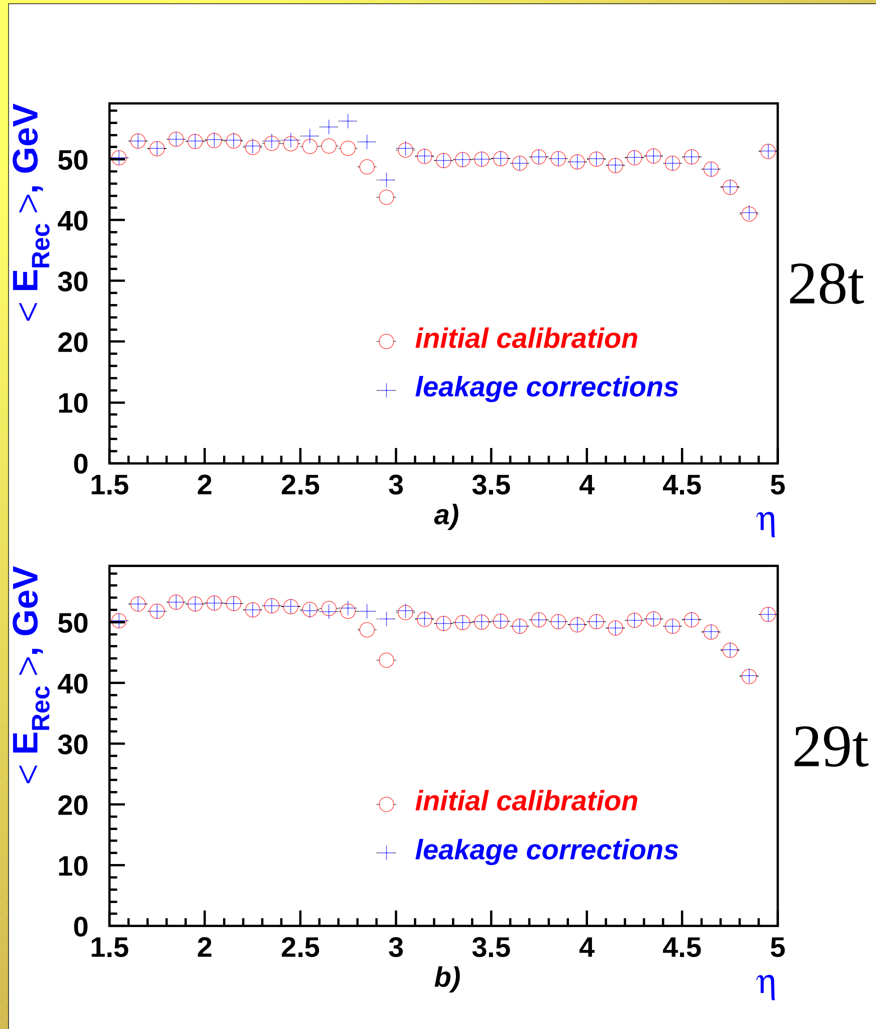
−> bookkeeping ***(with DSC team)***

−> ORCA−DB interface ***(with HCAL software and simulation)***

Hermeticy: HE−HF

A.Krokhotine

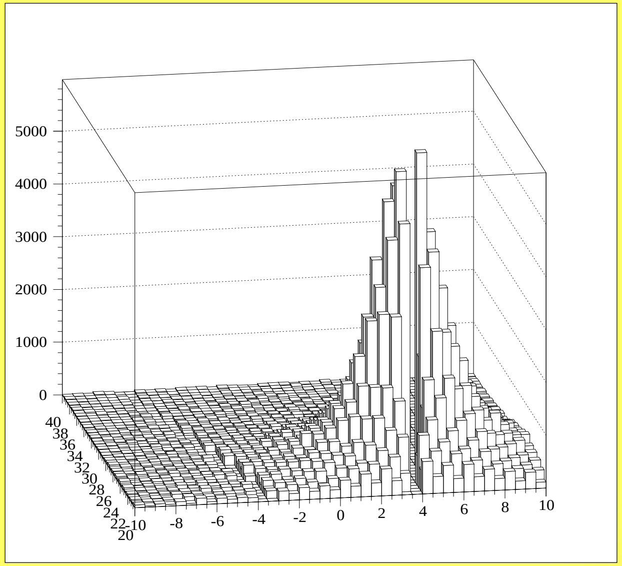




Hermeticy: boundaries between HF wedges

V.Kolosov

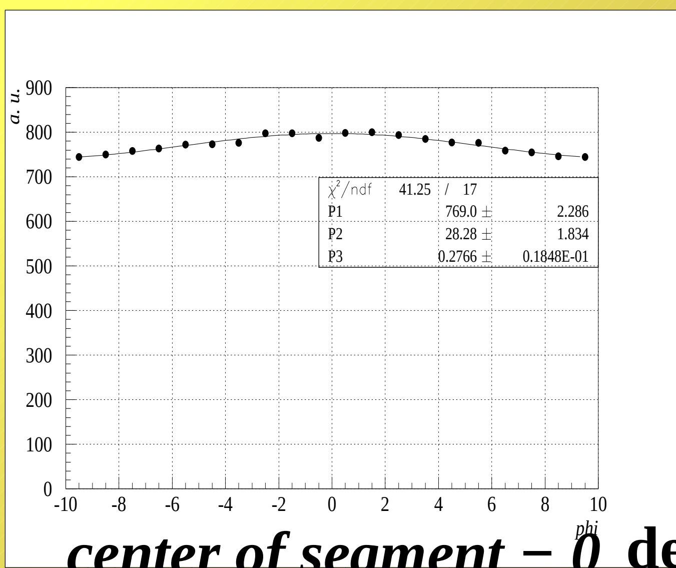
Nphe



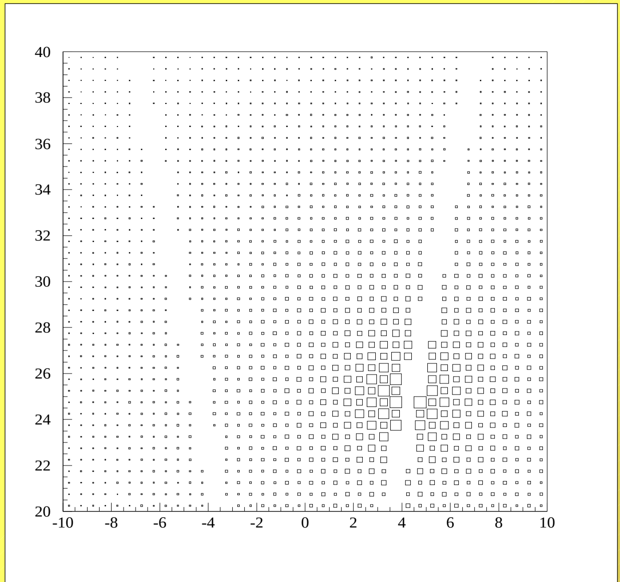
1000 jets

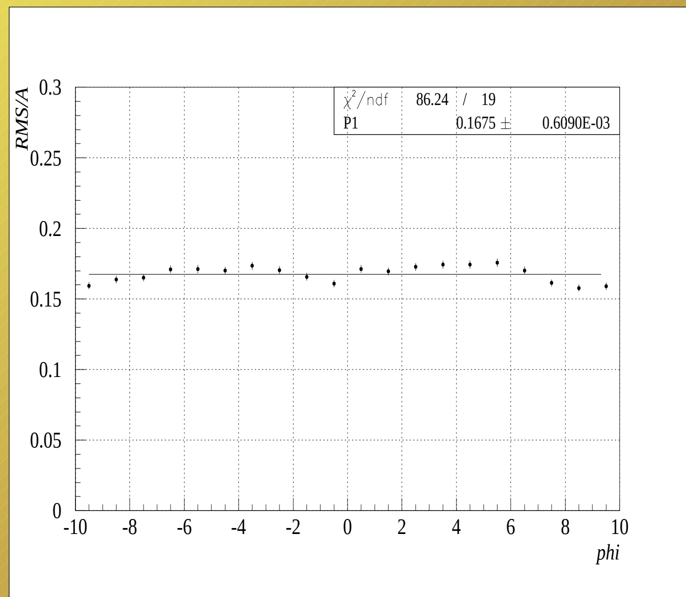
1 TeV jet

η=4.5



***center of segment − 0* deg**





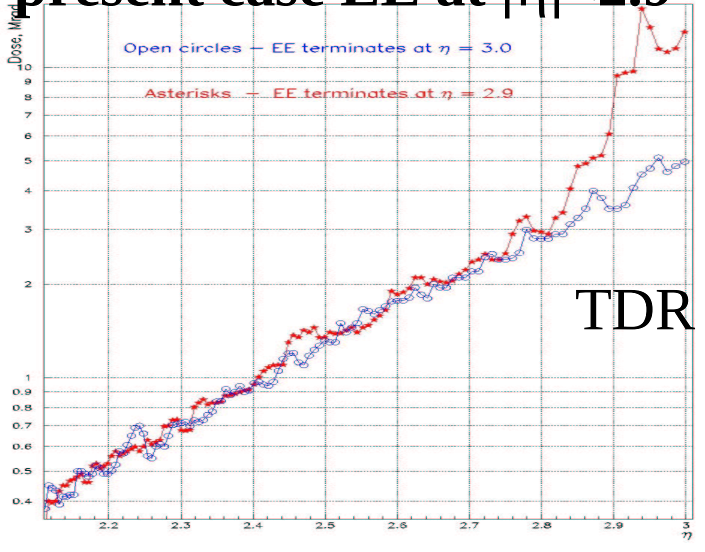
Radiation damage of HE

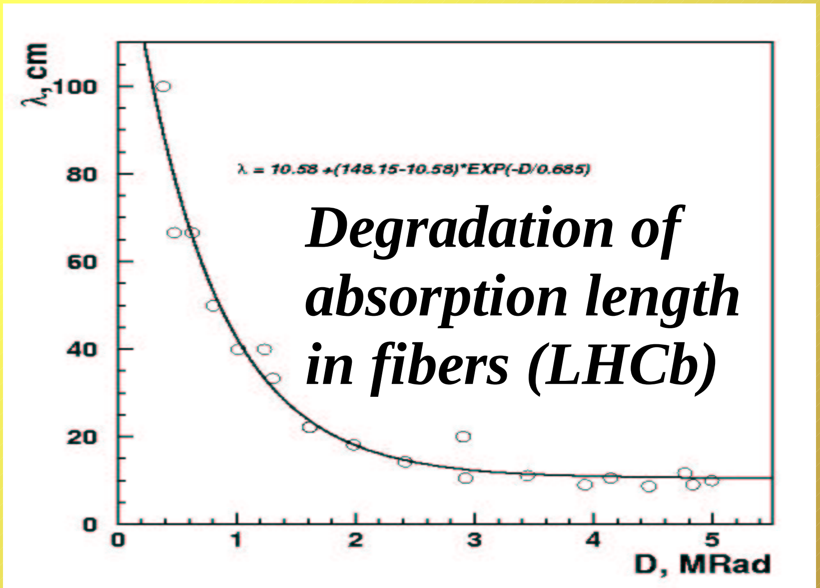
A.Krokhotine

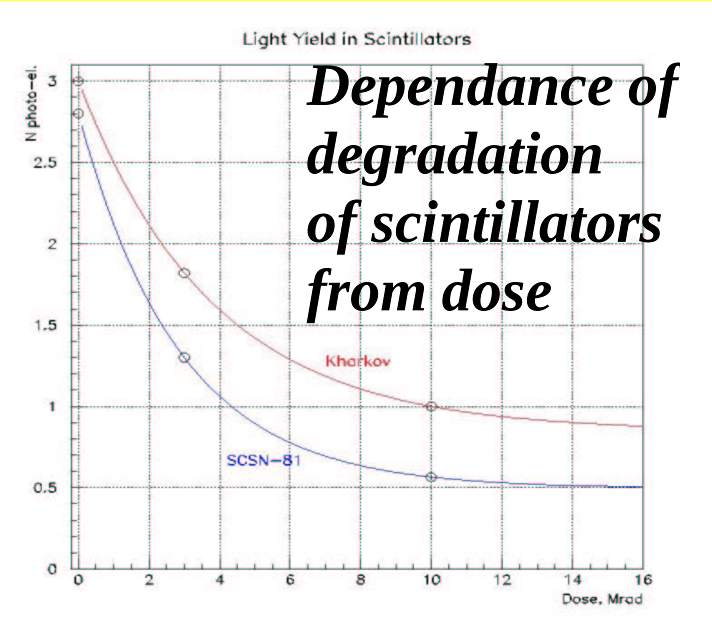
10 Mrad−>

Radiation doses in endcap for 10 years

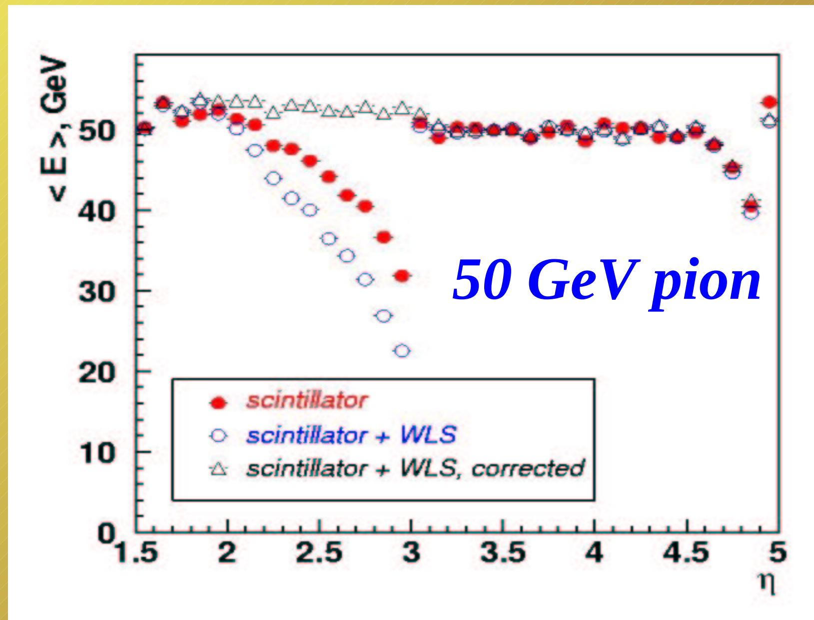
present case EE at |η|<2.9





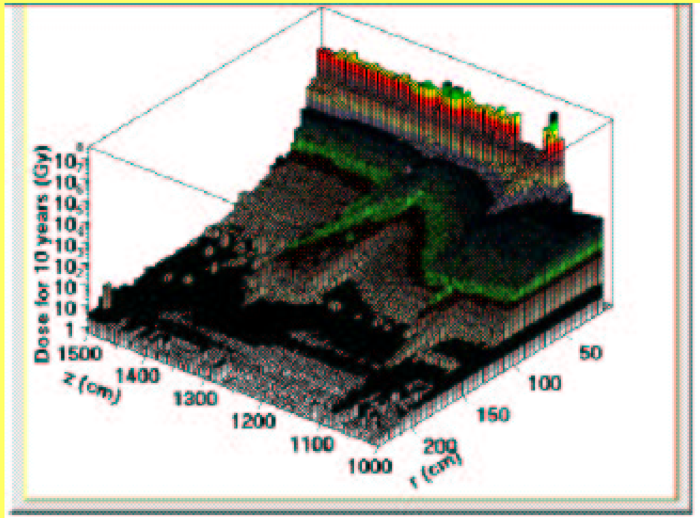


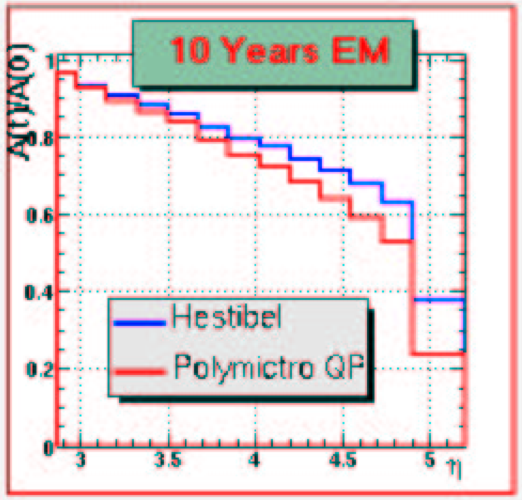
How many min bias for correction?

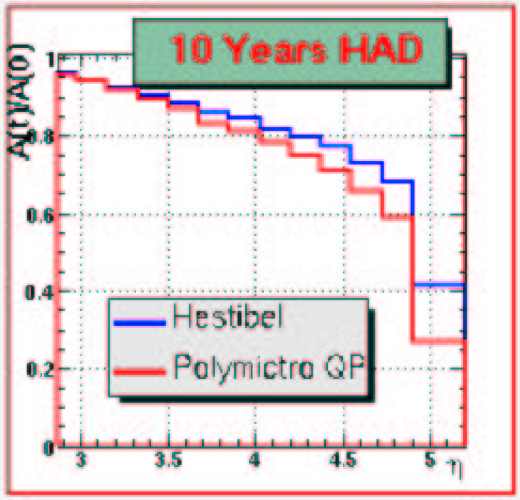


Radiation damage in HF (#1)

A.Gribushine



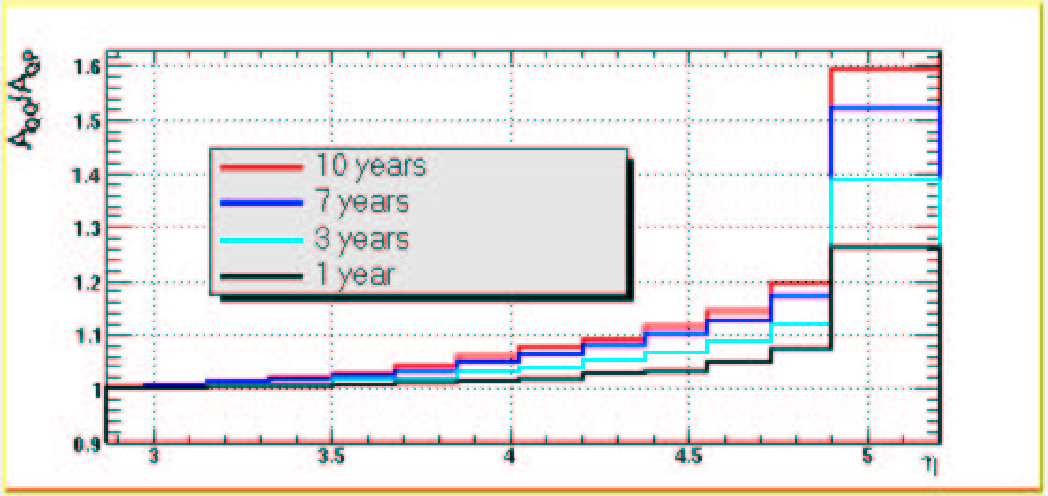




- >2K of Minimum Bias events ~400K p.e.
- CMSIM 125
- HF response with the shower library

Signal was then attenuated with parameters for Hestibel quartz-quartz and Polymicro quartz-plastic fibers

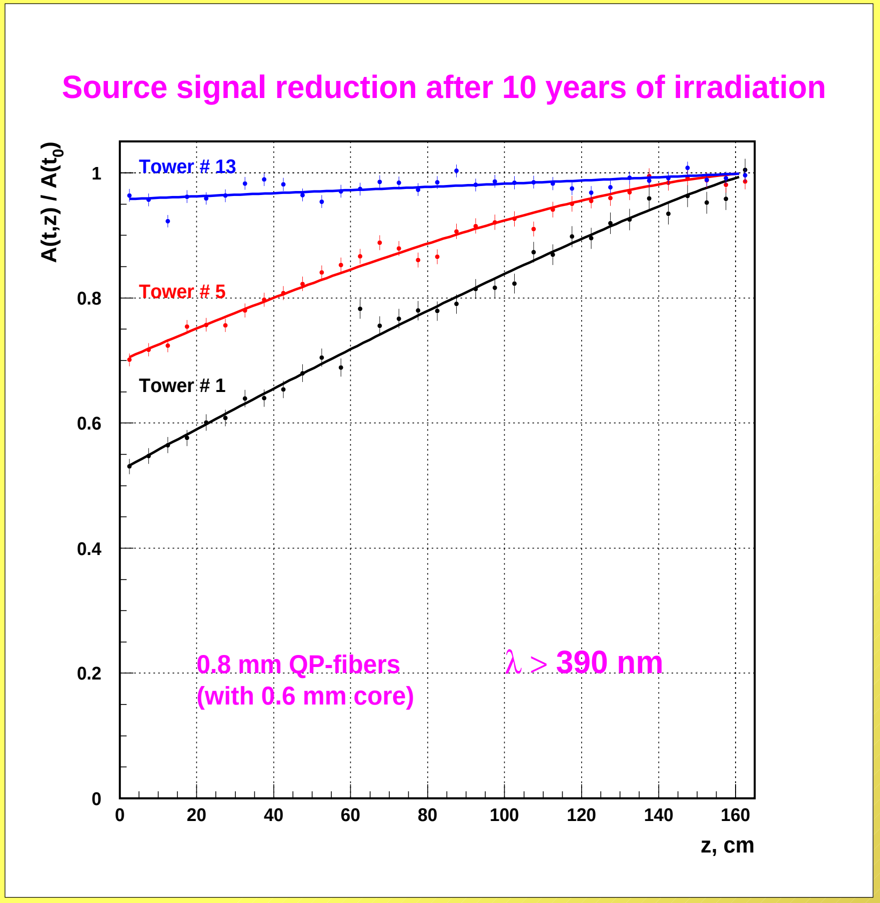
For the central towers ~60 to ~75% of the signal is lost after 10 years of operation

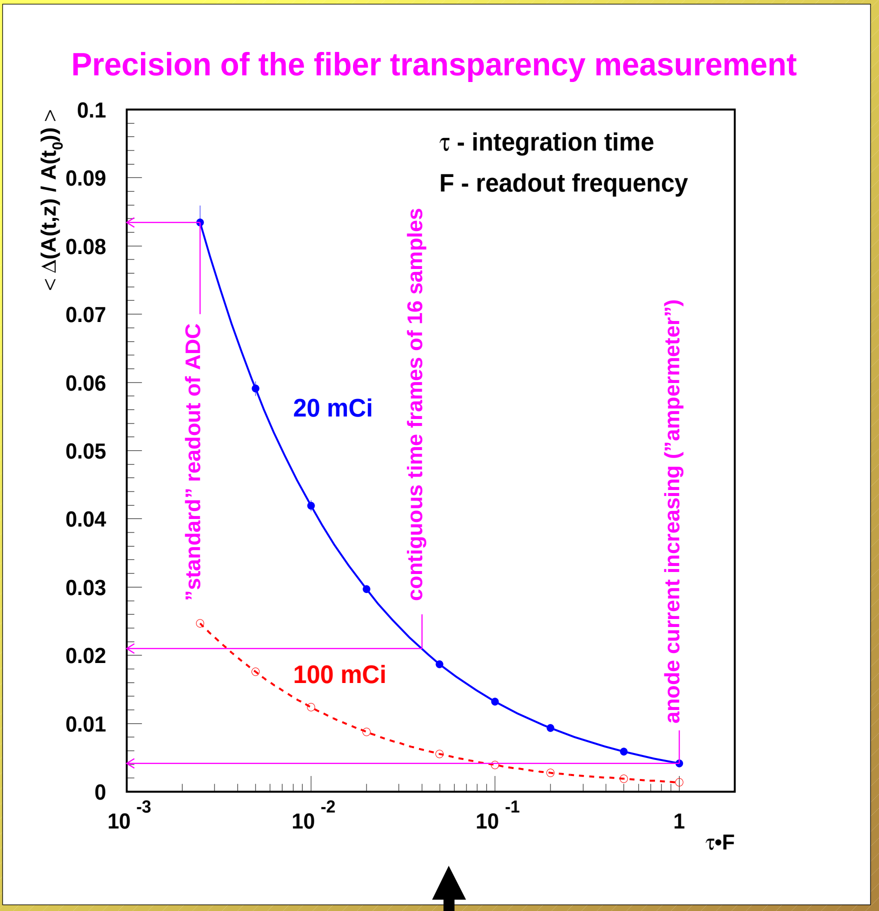


Possible corrections with min bias. statistics?

Radiation damage in HF (#2)

A.Erchov





Source is moving with speed 10 cm/sec. During each single measurement it passes 5 cm. i.e. 0.5 sec with 0.04% of integration time.

% of full integration time for each point

In Situ Calibration

(Physics Event Trigger)

A) Min−bias events trigger

- − estimation of pile−up energy.
- − normalization within each eta−ring.
- − isolated low E_T charged tracks ($|\eta|<2.4$)

2% accuracy with 1k events in HF

B) QCD Jet trigger (pre−scaled)

- − normalization within each eta−ring
- − normalization at the HB−HE−HF boundary
- − test on uniformity over full η range.
- − dijet balancing to normalize E_T scale in η rings.

($|\eta|<5$)

C) tau trigger

- − isolated high Et charged tracks (Et>30GeV) ($|\eta|<2.4$)

D) muon trigger (isolated)

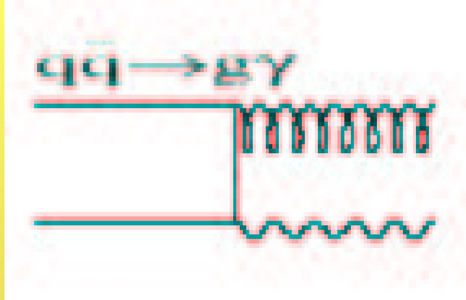
($|\eta|<2.4$)

- − good for monitoring.
- − probably too small energy deposit for calibration.

In Situ Calibration (2)

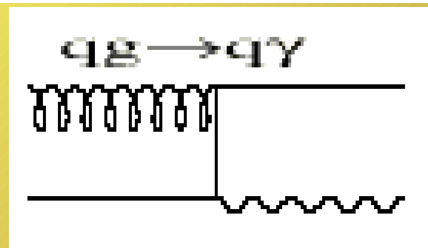
E) 1 photon + 1 jet (Victor Konopliniakov)

− E_T Scale over full η range by photon−jet balancing ($|\eta|<5$)



F) Z (−> ee, $\mu\mu$) + 1 jet (Anarbay Urkinbaev)

− E_T Scale over full η range by Z−jet balancing ($|\eta|<5$)



G) Top trigger (1 lepton + jets + 2 b−tags) (Suman Bala(?))

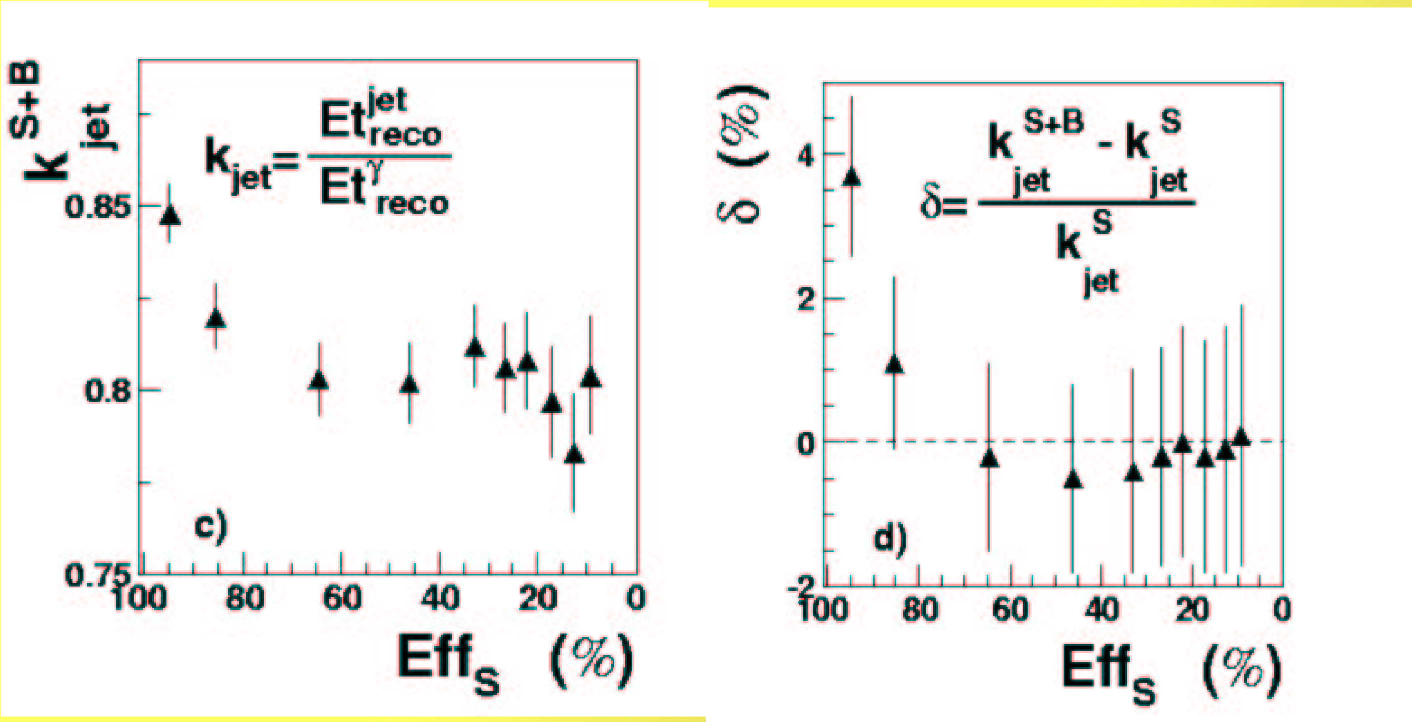
− E_T scale by Mass(jj) for W in Top decay. ($|\eta|<5$)

Need good understanding of trigger requirements and data streaming

γ+jet calibration (#1): background influence

V.Konopliannikov

E_T^{γ} = 40 −100 GeV, most of jets 30−60 GeV



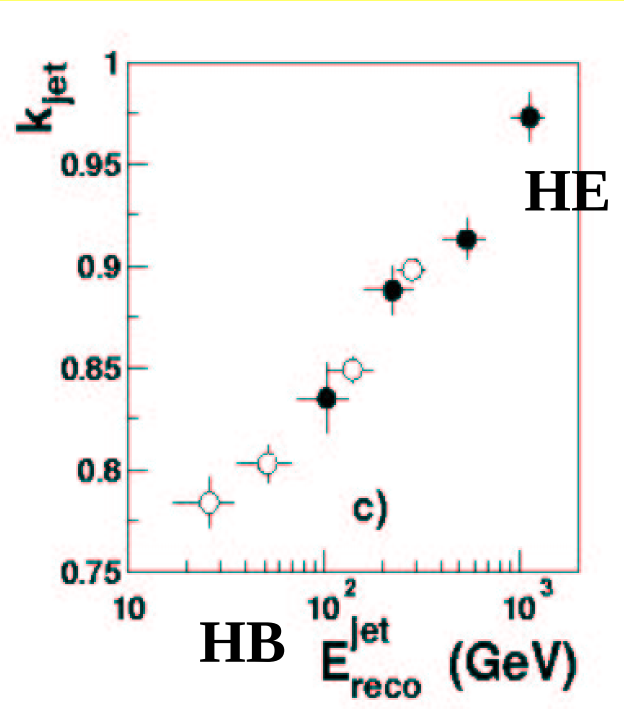
Cuts (example):
ETjet2<20 GeV
ETout1<27 GeV
$\Delta\phi$>2.73
ET_{isol}^{γ}<2.3 GeV

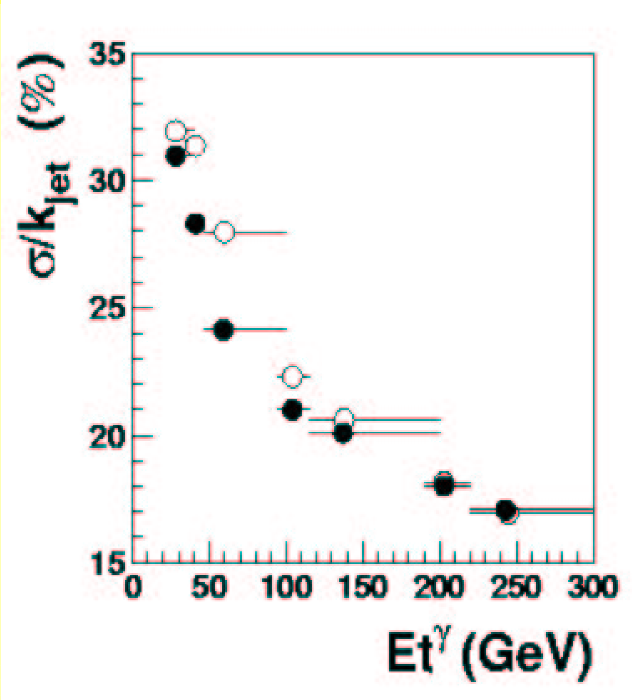
Efficiency of signal

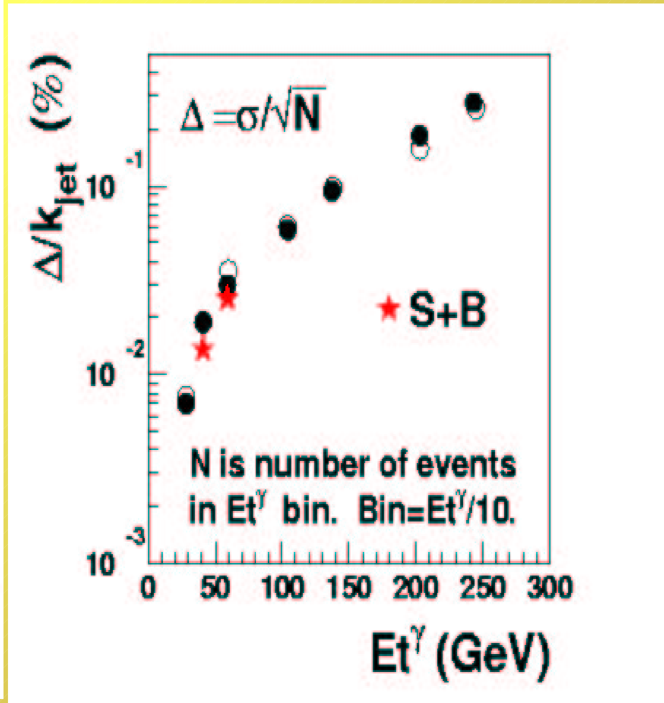
Systematical deviation due to background inclusion

Background events do not disturb events beginning from 50% signal suppression level.

γ+jet calibration (#2): errors







For 3 months − 2.5*10^{6} sec (5 fb^{-1})

$E_T^{\gamma} = 20 - 300$ GeV

Signal efficiency (%)	*Number of event*	*S/B*	*error (σ/(k*sqrt(N)) %*
50.00%	$10^8 - 10^4$	1	0.008 − 0.3
10.00%	$2*10^7 - 10^3$	2	0.015 − 0.5

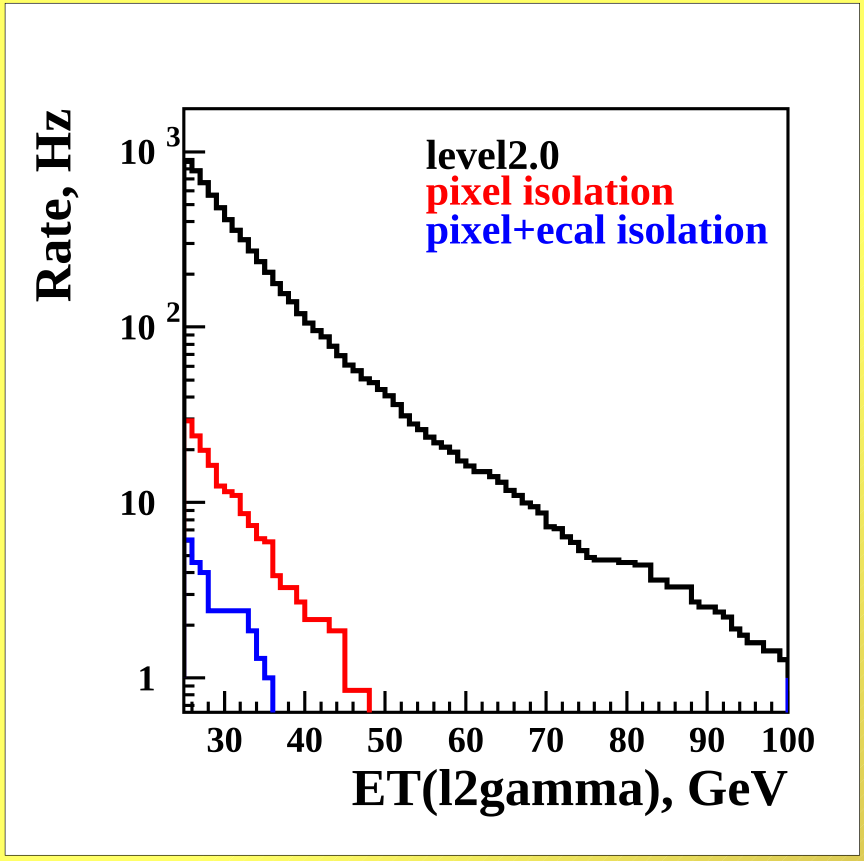
No pixel isolation

Time will increase considering trigger condition

γ+jet calibration (#3): trigger rates

A.Oulianov

Pixel and ECAL isolation



Only background sample

L2 gamma in |η|<1.5

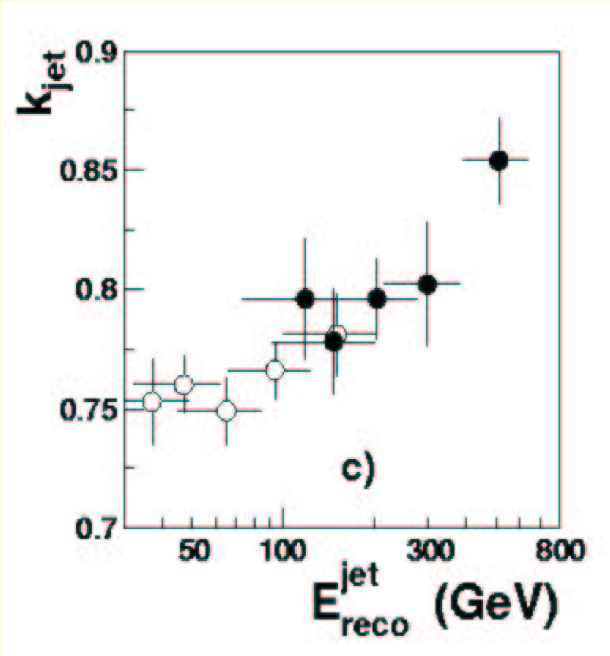
No pixel lines (PT>1 GeV/c) inside cone R=1 around L2 gamma

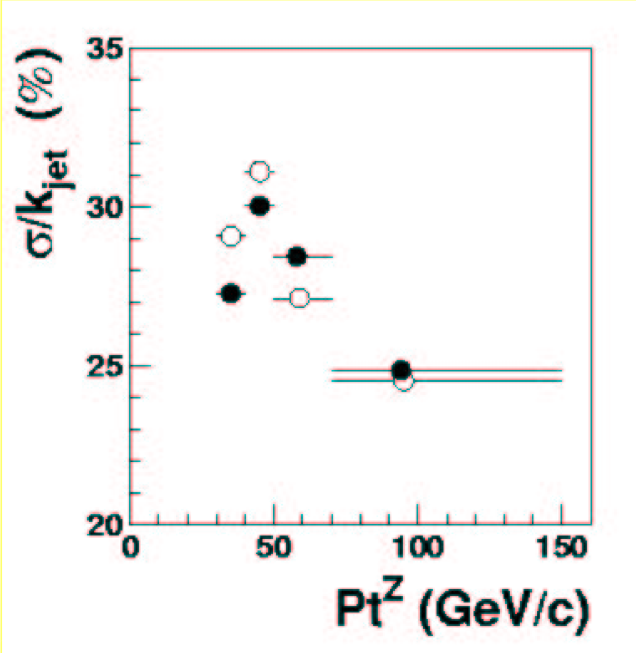
Sum of ECAL digis ET (above 100MeV) in the range 0.07<R<0.5 required to be less than 1.2 GeV

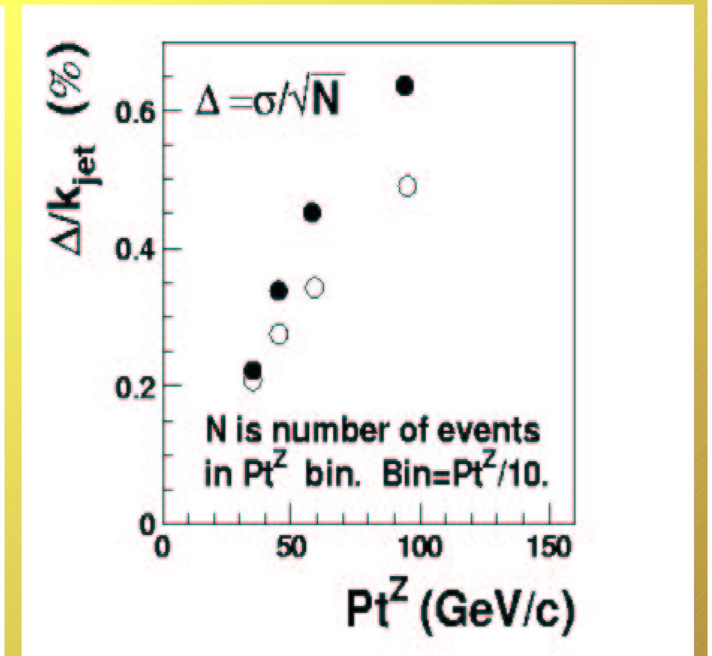
With signal rate will be ~4 Hz. Probably prescaling will be usefull

Z+jet calibration: errors

A.Urkinbaev







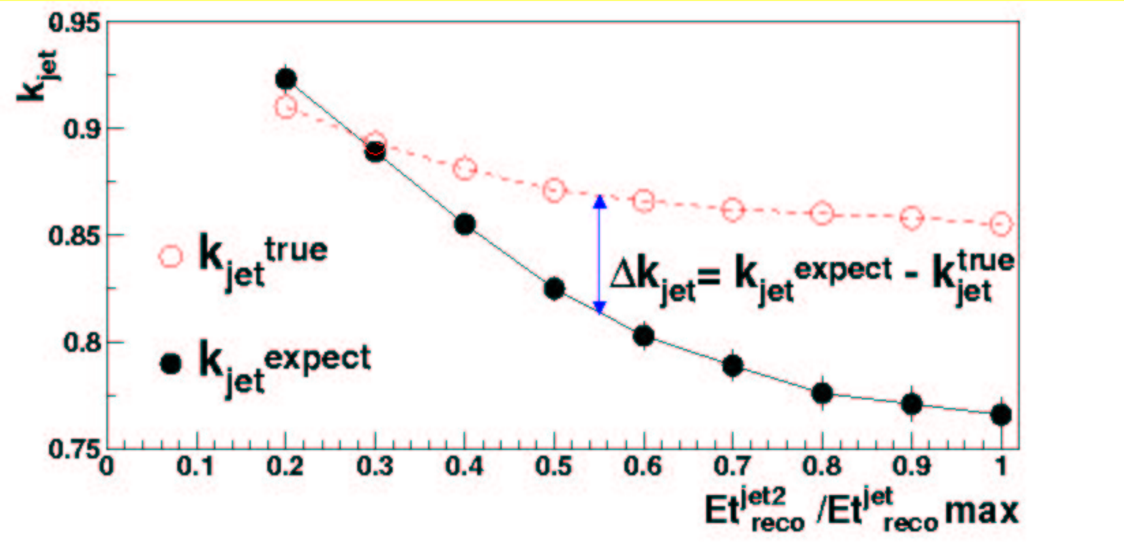
For 3 months − 2.5*10^6 sec

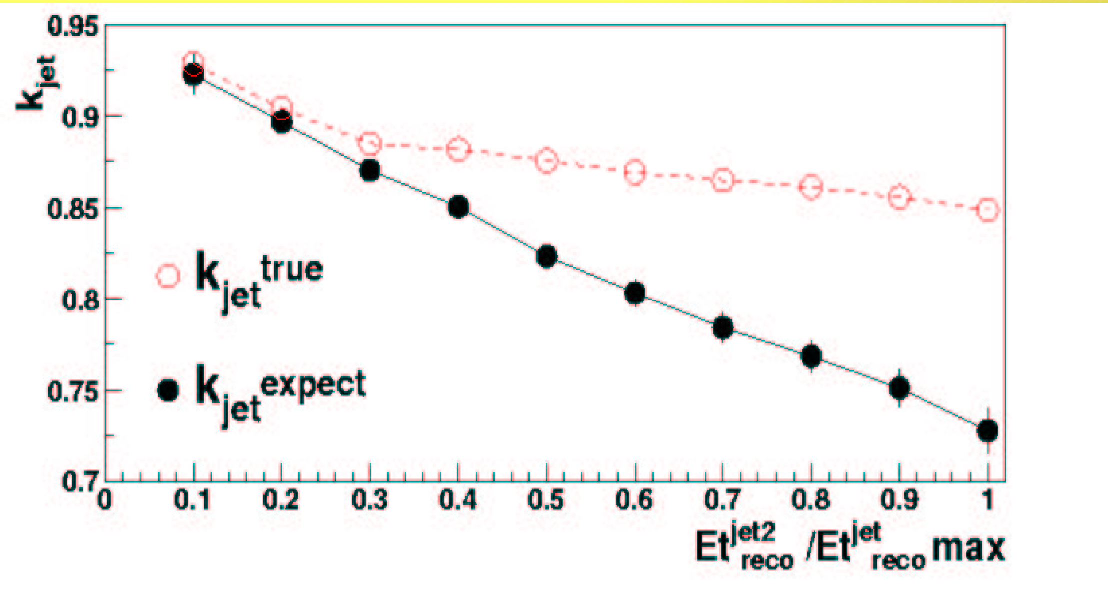
E_T^Z = 20 −100 GeV

Signal efficiency (%)	*Number of event*	*error (σ/(k*scrt(N)) %*
70.00%	$10^5 - 10^4$	0.2−0.5

No problems with trigger rate

γ/Z+jet: conditions for calibration





K_{exp} −> peak of $E_{Tjet}^{reco}/E_{T}^{\gamma/Z}$

K_{true} −> peak of $E_{Tjet}^{reco}/E_{T}^{particles}$

$E_{T}^{particles}$ can be estimate from other methods (with tracker f.e.)

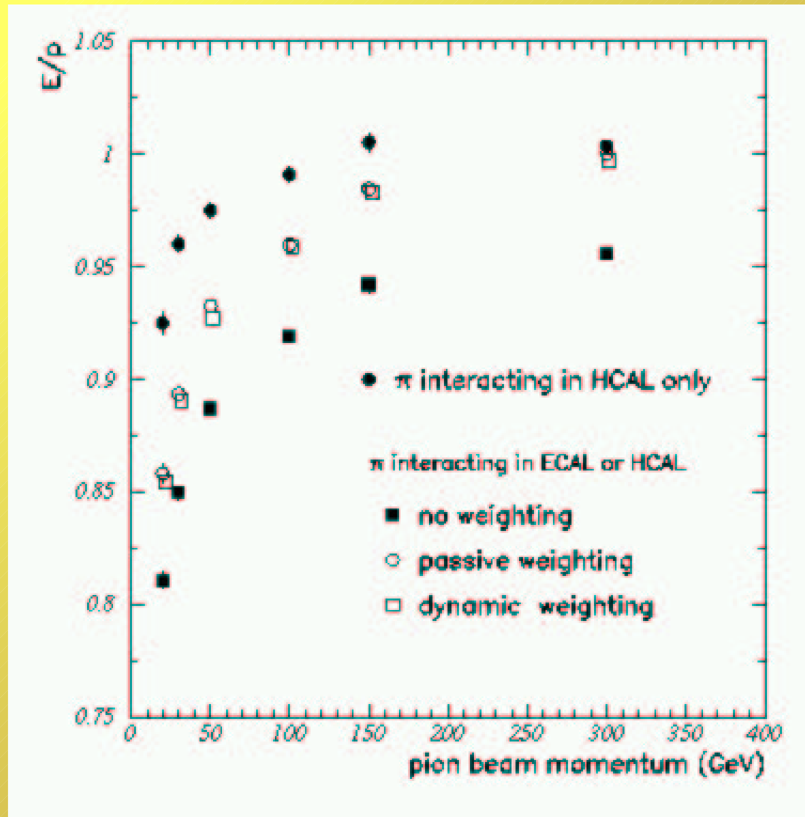
HLT Jets/MET and Energy Corrections (#1)

From jet physics (from parton to jet on particle level):

Fragmentation, ISR+FSR, underlying event, pile−up

From detector performance:

Magnetic field, noise, cracks, leakage, different response for e/gamma and hadrons etc



E/π for HCAL (1996 beam test) non−linearity up to 15 %

HLT Jets and Energy Corrections (#2)

Two steps for HLT jets

- ***Find jets with R=0.5 –1.0 with fixed calorimeter weights.***
- ***Correct energy scale to sharpen turn on curve.***

Energy Correction

- ***Jet based***

1) E = a x (EC+HC), a depends on jet(ET,η)

2) E = a x EC + b x HC, a, b depend on jet(ET,η)

- ***Particle based***

3) E = em + had (requires to separate em/had clusters)

em = a x EC for e/γ

had = b x EC + c x HC, for had. b (c) depend on EC (HC)

- ***Use of reconstructed tracks***

4) E = E_0 + (Tracks swept away by 4T field)

5) E = EC(e/γ+neutral) + HC(neutral) + Tracks

Jet Response and Correction #1

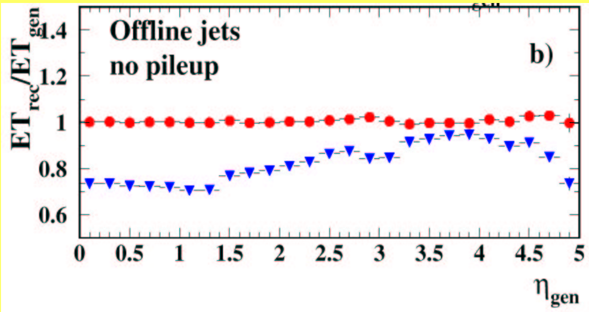
Et−eta dependent correction for QCD jets

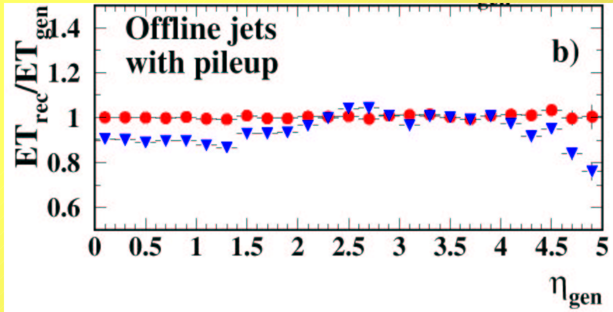
A.Krokhotine

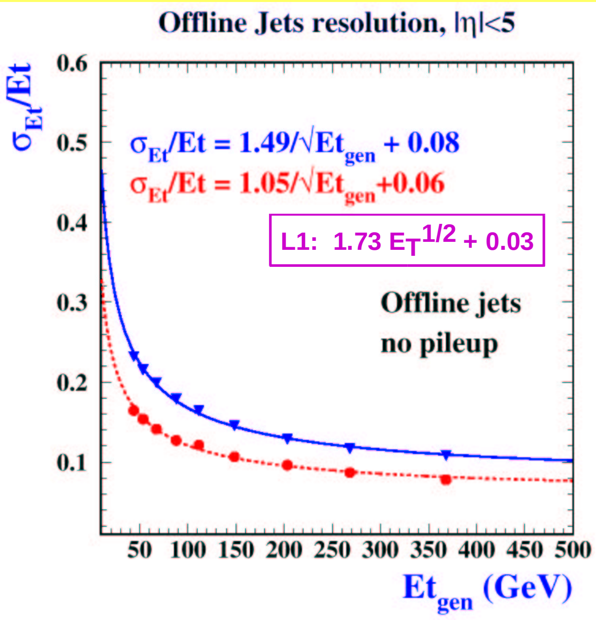
$Et(corr) = a + b \times E_T(rec) + c \times E_T(rec)^2$

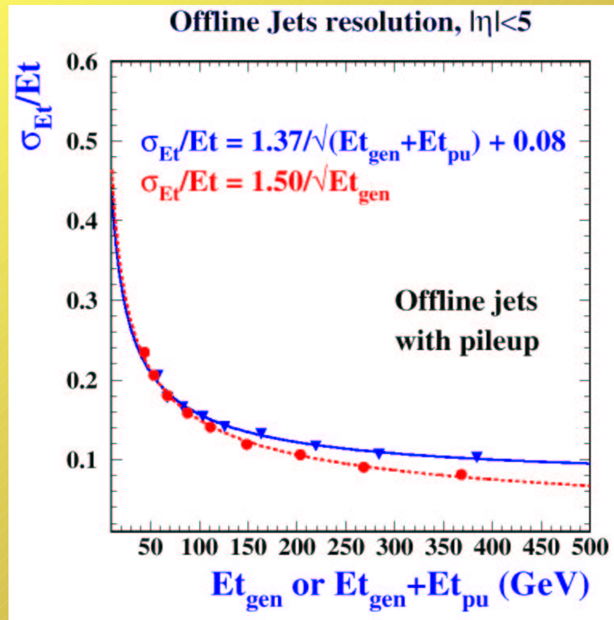
No pileup

With pileup

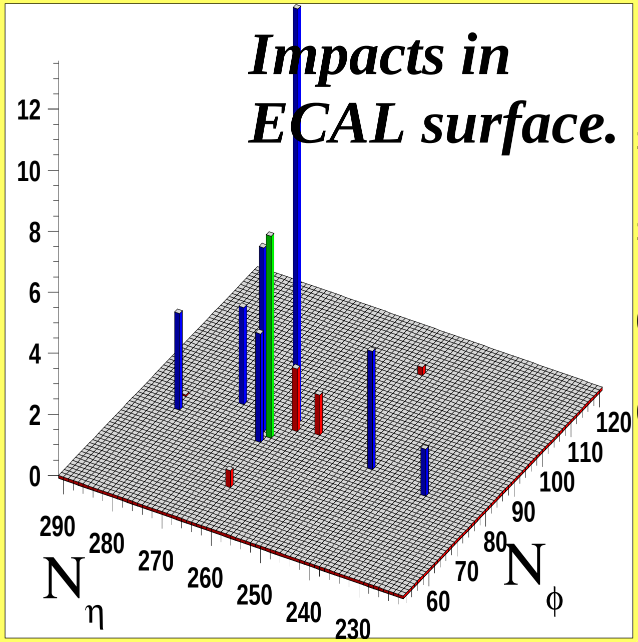


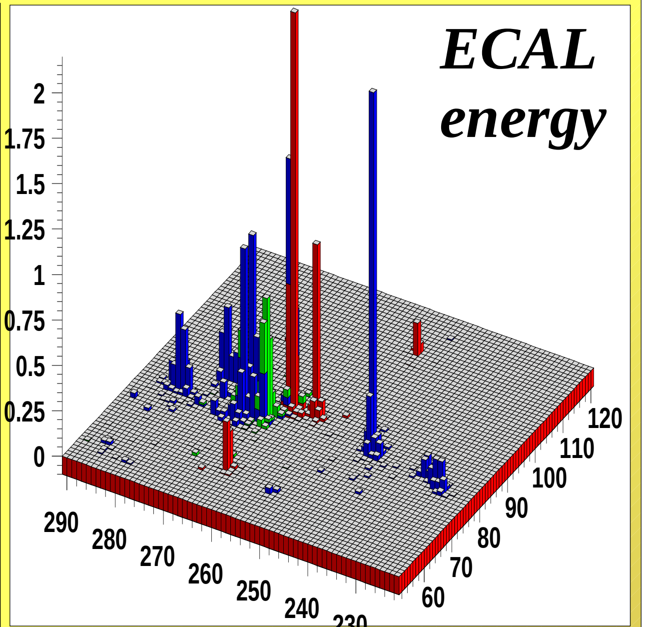


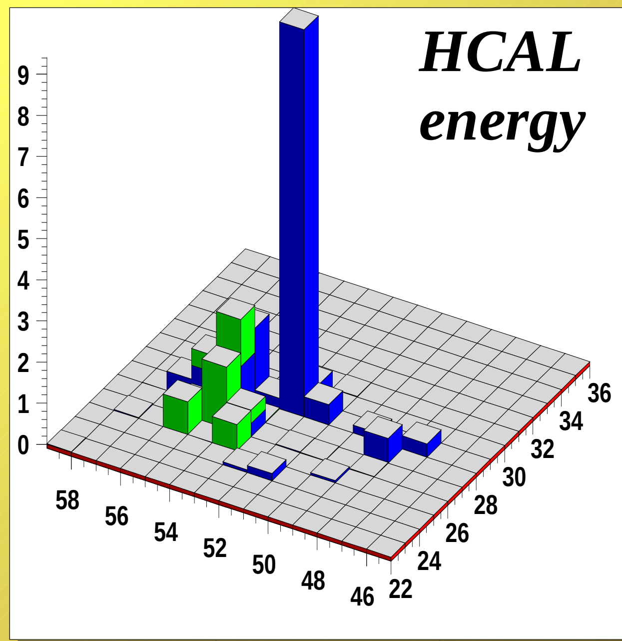




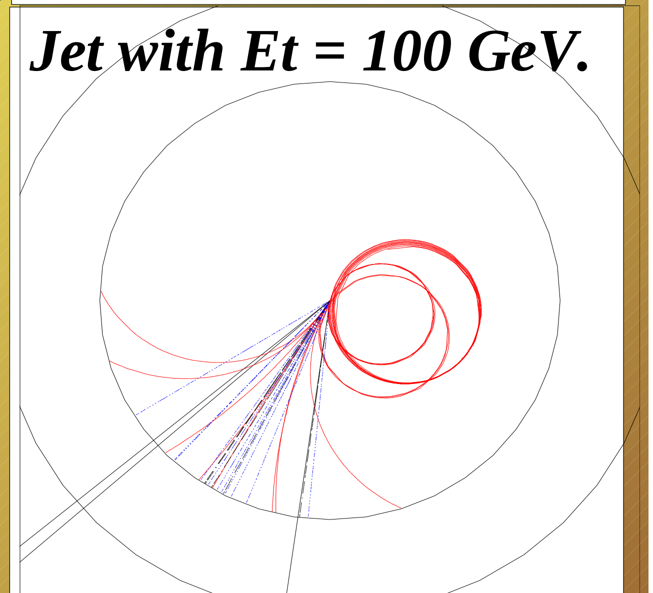
Using tracker information for jet energy corrections.







✔ *Example (A.Nikitenko): Jet with Et = 45 GeV.*



red − photons

blue − charged hadrons

green − neutral hadrons

$$E_{Tjet} = E_{Tjet}^{in\ cone} + P_T^{trks}$$

Jet energy=Response_charged+Response (e/γ)+Response (neutral)

- **Change response of charged hadron of jet to energy from Tracker**

Use energy flow objects inside reco cone (exchange isolated clusters associated with charged track to an energy from tracker)
D.Green.

For overlapping clusters subtract expected responce of matched tracks within cone and add $\sum P_T^{trk}$ from tracker.
I.Vardanyan, O.Kodolova

- *Use tracks of the jet with impact in calo out of the reco cone.*
A.Nikitenko (already made in ORCA with PixelReconstruction− see talk A.Nikitenko)

Result: Jet energy=E_TRACKER+Response (e/γ+neutral)_ECAL+ Response (neutral)_HCAL

Procedure 2 (Dan Green) : energy flow objects.

Z(120) events were used. ISR and FSR were switched on.

Isolated clusters in ECAL (3x3) crystals and HCAL (3x3 towers) were found.

Cluster classification:

photon

Cluster in ECAL has not associated hadronic energy.

hadron

Cluster in ECAL has associated hadronic energy of at least 30%.

charged hadron interacted in ECAL

If matched with tracker

hadron interacted in HCAL

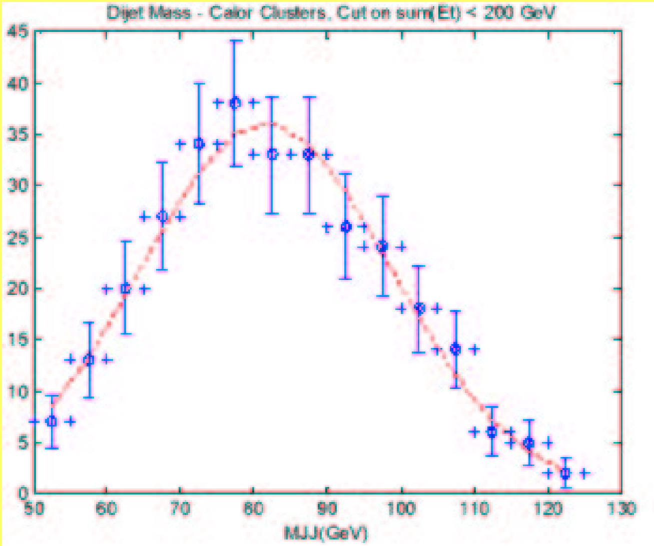
Cluster in HCAL without sufficient ECAL energy

All clusters within cone matched with tracks were extracted from E_{jet}^{calo} and P_T^{trk} was added instead.

$$E_{jet}=E_{jet}^{calo}-E_{clus}^{in\ cone}+P_T^{trks\ in\ cone}$$

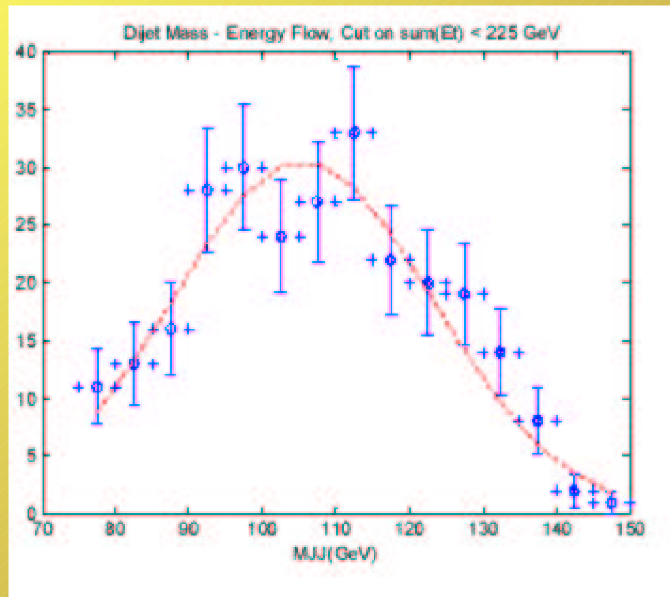
Dijet mass

Calo clusters only



Mean=81.7+−1.1 GeV
Sigma=17.1+−1 GeV

Calo clusters+tracker



Mean=105.5+−1.1 GeV
Sigma=17.1+−1 GeV

Procedure 3 (O.Kodolova, I.Vardanyan): response subtracting

- ✔ **Energy (R(ECAL), R(HCAL) is calculated in cone around jet axis using standard procedure and with default coeffients.**
- ✔ **Summarized averaged response from charged particles with entry point inside a cone is subtracted from R(ECAL), R(HCAL).**
- ✔ **Expected response was calculated in different ways:**

  e/π technique (1), library of responses(2), matched cluster(3) based on isolated particles.

e/π technique, energy flow objects = matched cluster

(D. Green, CMS NOTE's in draft).

$$E_{EM+neutral}(ECAL)=R(ECAL)-sum(R\_ECAL\_i)$$

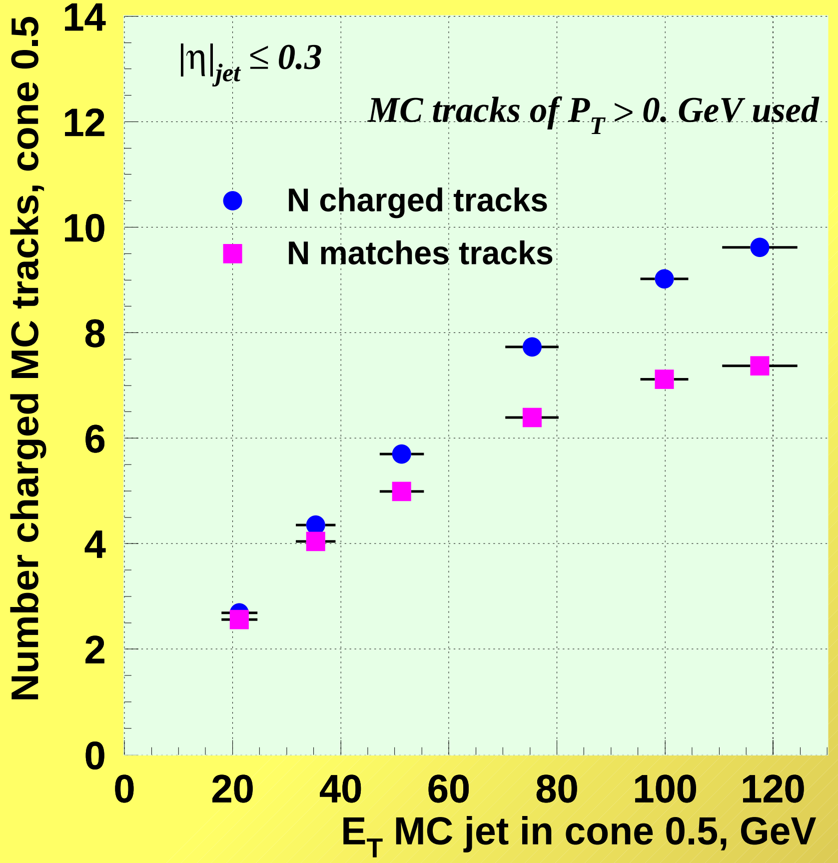
$$E_{neutral}(HCAL)=R(HCAL)-sum(R\_HCAL\_i)$$

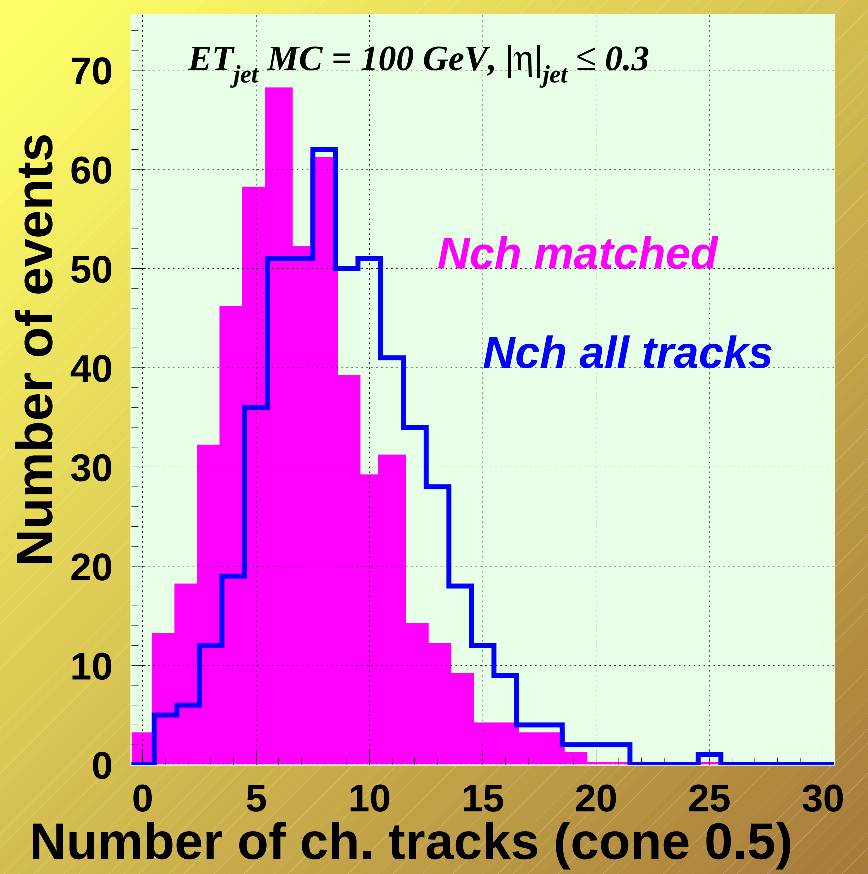
$$Etracker=sum(Etracker\_i)$$

$$Ejet=E_{EM+neutral}(ECAL)+E_{neutral}(HCAL)+Etracker$$

- ✔ **Tracks out of cone were added (A.Nikitenko)**

Mean number of all charged particles with hit within reco cone and mean number of particles matched with clusters for different jet energy (left figure). Distribution the number of all charged and charged matched with clusters for jet energy 100 GeV (right figure).



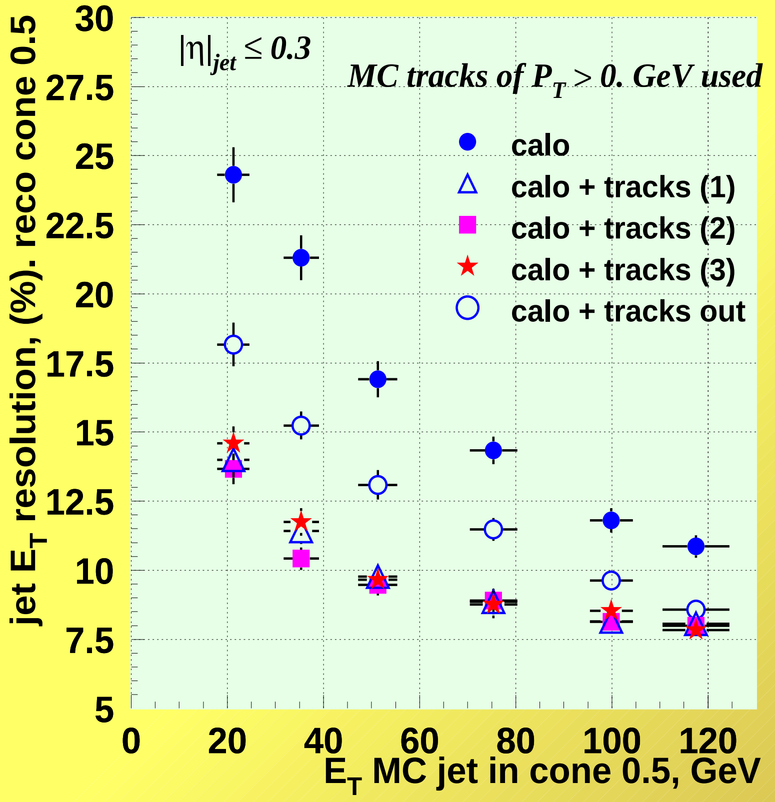


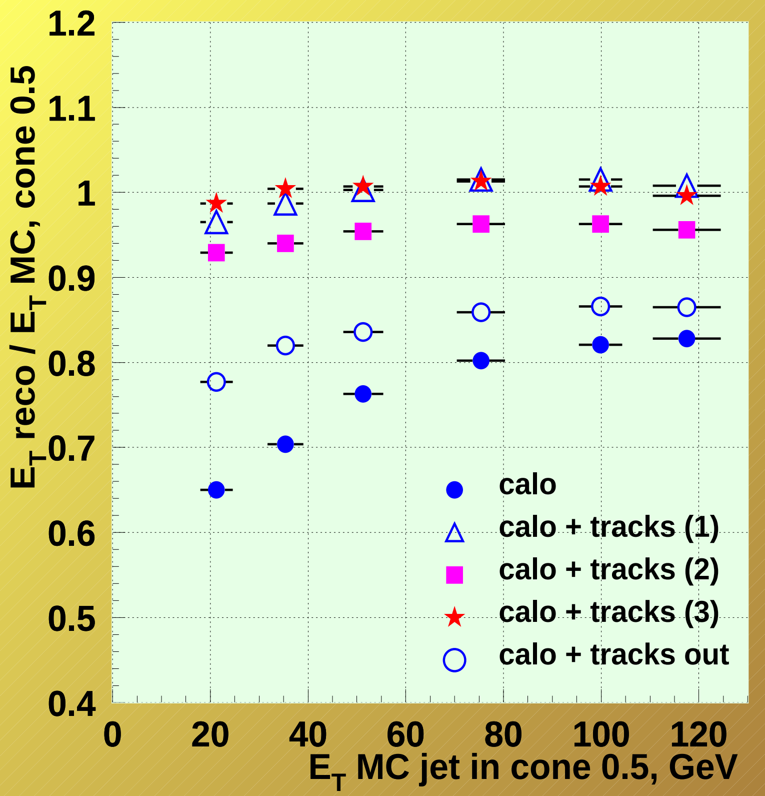
Resolution and mean ETrec/ETgen for different MC jet energy.

Three options are used for calculating expected response: e/π technique (calo+tracks(1)), library of responses (calo+tracks (2)), matched clusters+library of responses (calo+tracks(3))

for 20 GeV: from 24% to 14%

for 100 GeV: from 12% to 8%





Why for expected response subtraction $D(E_{jet}^{rec}/E_{jet}^{gen})/\langle E_{jet}^{rec}/E_{jet}^{gen}\rangle$ should be better:

Only calorimeter information:

$$E_{jet}^{calo}=\sum Response\ (e/\gamma)+\sum Response(neutral)+\sum Response(charged)$$

$$D(E_{jet}^{calo})=\sum D(Response(e/\gamma))+\sum D(Response(neutr))+\sum D(Response(char))$$

Include Tracker information:

$$E_{jet}^{tracker}=\sum Response\ (e/\gamma)+\sum Response(neutral)+\sum Response(charged)-$$

$$-\sum Response(charged)\_teor+\sum Etracker=$$

$$=E_{jet}^{calo}+\sum Etracker-\ \sum Response(charged)\_teor$$

$$D(E_{jet}^{tracker})=D(E_{jet}^{calo})+\sum D\left(Etracker\right)+\sum D(Response(charged)\_teor)=$$

$$=D(E_{jet}^{calo})$$

Statistical error is kept unchanged but mean energy become closer to it's value on generator level. But there is a systematical error connected with expected response calculations.

Minimization of systematical error can be made with Z−>jj for example.

Summary

- ✓ ***Collection and maintenance of calibration data (participate in DCS group activity):***

  Clarify tasks/responsibilies for operation, analysis, collection, maintenance etc.

  Participate in testbeams

  Volodia Ladygin is database manager (please, send him any new information:ladygin@sunhe.jinr.ru)

- ✓ ***In−situ calibration:***

  - ***trigger and data stream requirements. Two independent investigations show that rate of γ+jet channel with calorimeter and pixel isolation will be on the level of 4 Hz (ET>30 GeV). It should not be any problem with Z+jet channel (rate 0.04Hz). We intend to use ttbar and expect no problems with trigger.***

  - ***backround influence and conditions for calibrarion.***
    Beginning from the definite level of signal suppression (50%) the influence of background on calibration with γ+jet channel and Z+jet channel becomes small enough (less then 1 %). Using cut on the energy of second jet one can achieve the condition when ratio $E_{calo}^{jet}/E^{\gamma}$ and $E_{calo}^{jet}/E_{part}^{jet}$ becomes close with accuracy about 1%.

Two steps for jet energy corrections: find jet with default fixed coefficients and correct with one of the methods.

- ***Including tracker information to jet energy measurement gives essential improvement of the jet energy resolution:***

  for 20 GeV: from 24% to 14%

  for 100 GeV: from 12% to 8%

  so as jet energy linearity

  The next step is to include full reconstruction in tracker and should be implemented in orca.

- ***Include different corrections for different jet reconstruction algorithms***

- ***Different calibration channels will be used in complementory mode to achieve the better performance for energy recoverment.***

- ***hermecity. Perform recalibration with pile up events and selected processes to achieve uniform distribution in eta of energy deposition***

✓ ***Monitoring:***

- ***radiation damages. Endcap and HF part of HCAL will have essential degradation of signal. Corrections can be performed both source and in−situ physical channels.***

- ***dead and noisy channels***

– candidates –

– PRS –	– DCS –
A.Gribushin	P.DeBarbaro
H.Budd	V.Bernes
V.Kolosov	
I. Vardanyan	
A.Kokhotine	
P.Hidas	
V.Konnoplianikov	
A.Yershov	V.Hagopian
K.Teplov	
A.Oulianov	
T.Kramer	
S.Abdullin	
V.Ladygin	

Calibration

Calorimeter level energy scale

initial calibration: test beam+source

verify QC during HCAL construction

Object level energy scale (Jet/Met)

Simple /use of tracks/In−situ/pileup

Monitoring

Synchronization

Gain change,Dead/sick channels

Radiation damage

Software tools

Database

Interface

DSC/DAQ−DB interface

ORCA−DB interface

Data Collection and maintenance

Need more names,

Esp. from HB/HO